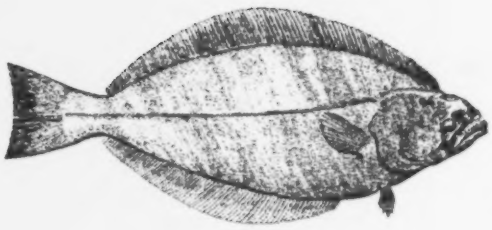
Pêches et Océans Canada | Fisheries and Oceans Canada
Sciences | Science
Quebec Region
Canadian Science Advisory Secretariat
Science Advisory Report 2011/013

ASSESSMENT OF THE GREENLAND HALIBUT STOCK IN THE GULF OF ST. LAWRENCE (4RST) IN 2010



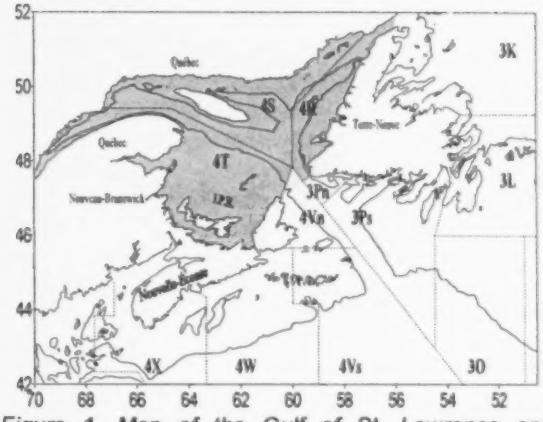


Figure 1. Map of the Gulf of St. Lawrence and neighbouring regions showing NAFO divisions 4RST.

Context

Until the mid 1970s, Greenland halibut (also called black turbot, or more commonly turbot) from the Gulf of St. Lawrence (4RST) were not subjected to any directed fishery. At the end of the 1970s, a Greenland halibut fishery developed using gillnets and bottom trawls.

Because the Atlantic cod mobile gear fishery was closed in 1993, any mobile gear directed fishery for Greenland halibut has been prohibited. This fishery is now dominated by boats equipped with gillnets, whose homeports are located in Quebec or on the west coast of Newfoundland.

Since 1982, the Greenland halibut fishery has been managed by controlling total allowable catches (TAC). This TAC management helps limit exploitation in order to protect the population's reproductive potential. Over the years, Fisheries and Oceans Canada (DFO) has implemented other conservation measures that have helped reduce the number of immature fish caught. However, minimum biomass or maximum exploitation rates that could jeopardize the resource are unknown. Also unknown is the optimal exploitation rate which could help set precise targets.

The main information used to evaluate this resource is biomass indices from DFO research surveys and sentinel fishery surveys conducted each year in July, evolution and strength of cohorts that will be recruited to the fishery, size at sexual maturity for each sex and the fish condition index. Catches per unit of effort (CPUEs) from traditional gillnetters using 6 in. mesh nets, the mean size of fish caught as well as standardized indices of exploitable stock biomass (44 cm and above) from fishery CPUEs and surveys are also used as indicators of stock status and fishery success.

Greenland halibut population assessment is done every two years in order to highlight changes in the status of the resource that would justify adjustments to the conservation measures and management plan.

July 2011

Canada

SUMMARY

- Preliminary landings of Greenland halibut by the fixed gear fleet totalled 3,782 t as of December 2010 of an available allocation of 3,751 t. However, fleets can land another 262 t in individual quotas prior to May 15, 2011.
- The proportion of females caught in the fishery was 80 % in 2010 and has remained more or less the same since 2000.
- The proportion of individuals in the fishery smaller than the legal size of 44 cm dropped from 19% in 2008 to 12% in 2009 and 9% in 2010. At this size, 63% of females and 5% of males were immature. Mean size increased by 1.1 cm to 49.3 cm from 2009 to 2010.
- The size at which 50% of fish are mature has remained rather low since 2001 (males 36.3 cm and females 45.4 cm).
- The fleet's fishing sites have changed since 2006, fishing activities have dropped in the estuary (area known for small turbot) and fisheries have developed around Anticosti (southwest and north).
- Commercial catch rates have been high and stable since 2007, but dropped slightly in 2010 compared to 2009. A small drop was observed in Esquiman, northern Anticosti and in the western Gulf.
- The significant decline observed in the biomass indices (kg/tow) from the two surveys from 2007 to 2009 has stopped in 2010, but the indices are still below the average of the last ten years.
- The 2004 strong year-class significantly contributed to the 2010 fishery, which could explain the increase in mean size. Its contribution should decrease in 2011 and 2012. The 2005, 2008 and 2009 cohorts were weak according to the two surveys and are likely to reduce the exploitable portion over the next few years.
- Even though the exploitable biomass is in the "healthy" zone based on the preliminary reference points, it may decline in the medium term due to the arrival of these three less abundant year-classes.
- Given that the main indicators of resource status and that the mean abundance of the upcoming year-classes (2006 and 2007) indicate that the fishery is stable, the status quo is recommended for the catch levels allowed in 2010 for 2011-2012 and 2012-2013.

INTRODUCTION

Species Biology and Background Information

The Greenland halibut population of the Gulf of St. Lawrence is considered to be a stock isolated from the main Northwest Atlantic population found east and north of Newfoundland's Grand Bank. Parasite studies conducted in the early 1990s showed that the Gulf population was

distinct, which led to the conclusion that Greenland halibut complete their entire life cycle within the Gulf.

Greenland halibut are generally found in the channels of the Gulf of St. Lawrence at depths ranging between 130 and 500 m (70-280 fathoms). Juveniles dominate the estuary and north of Anticosti. Spawning takes place primarily in winter, from January to March. Males reach sexual maturity at a smaller size than females. This difference helps explain why females grow to be larger than males and make up the majority of commercial catches.

Size at maturity for male Greenland halibut in the Gulf of St. Lawrence decreased considerably between 1996 and 2001 and has since remained generally below the series average (1996-2010).

Juvenile abundance varies a lot from one year to the next, and they are recruited to the fishery around the age of 5. The strength of these annual year-classes, their growth, as well as environmental conditions influence stock abundance fluctuations and have an impact on the fishery's success.

Description of the Fishery and Conservation Measures

All the fishermen's boats' homeports are located in Quebec and on the west coast of Newfoundland. Prior to 1999, the Greenland halibut fishery was essentially competitive. An individual quota pilot project was introduced in 1999 for traditional fishermen in Quebec in order to extend their fishing season. This pilot project became permanent in 2002. Beginning in 1999, the fishing season was modified in order to correspond with the year of the management plan, i.e. from the current year until May 14 of the following year (Table 1).

Table 1. Landings (thousands of tons)

Year	77-98 avg.	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011[1]
TAC	-	4.5[2]	4.5[3]	4.5[3]	3.5[3]	3.5[3]	4.5[3]	4.5[3]	4.5[3]	4.5[3]	4.5[3]	4.5[3]	4.5[3]
Fixed gear	3.1	3.4	2.0	1.2	1.6	3.5	3.8	3.8	3.8	3.6	3.7	4.2	3.7
Mobile gear	1.1	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
Total	4.2	3.6	2.1	1.3	1.7	3.6	3.9	4.0	3.9	3.7	3.8	4.3	3.8

[1] *Preliminary data*
[2] *TAC from January 1 to May 14, 2000*
[3] *TAC from May 15 of the current year to May 14 of the following year*

The number of active boats in the Greenland halibut fishery in the Estuary and Gulf was around 196 in 2010.

In addition to managing the fishery by total allowable catches (TAC), other conservation measures have been implemented since 1995 following recommendations from the Fisheries Resource Conservation Council (FRCC), which are aimed at reducing the fishing effort and the number of immature fish caught:

- increase in mesh size from 140 mm (5.5 inches) to 152 mm (6 inches);
- adoption of a more selective fishing net configuration;
- implementation of a small-fish tolerance protocol for commercial catches with a minimum size increasing from 42 cm in 1996 to 44 cm since 1997;
- establishment of a dockside monitoring program for commercial catches;
- voluntary reduction in the number of nets used by Quebec fishermen (from 120 to 80 nets) between 1996 and 2000.

Fishermen are also required to have an observer on board according to DFO requirements (5% coverage). Since 1993, because the Atlantic cod mobile gear fishery has been closed in the northern Gulf and because of the mandatory use of the Nordmore grate by shrimpers, recorded catches from mobile gear are limited to accidental catches and special projects (varying between 1% and 7% of the total catches).

Until the mid-1970s, Greenland halibut landings in 4RST consisted mainly of by-catches from other fisheries (Figure 2). Subsequently, a directed gillnet fishery developed and landings fluctuated substantially, exceeding 8,000 t in 1979 and 1987. These peaks were both followed by sharp drops. Catches remained between 2,000 t and 4,000 t from 1989 to 1998. Landings decreased by 67% between 1999 and 2001, dropping from 3,600 tons to less than 1,300 tons. This significant drop was indicative of the poor fishery results of 2001 and 2001, particularly for Quebec fishermen. Landings increased to 3,900 tons between 2001 and 2004 and have been relatively stable since. Between 1999 and 2001, TAC was set at 4,500 tons, and then dropped to 3,500 tons in 2002 and 2003. TAC has been increased to 4,500 tons since 2004 and the allocation for the fixed gear directed fishery for Greenland halibut was set at 3,751 t. In 2010, preliminary landings of the current year for NAFO Divisions 4RST totalled 3,782 t.

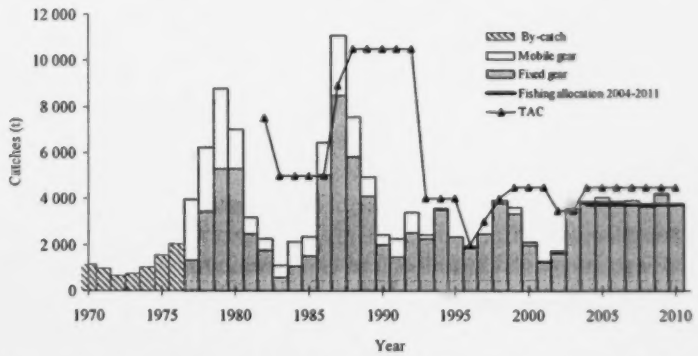


Figure 2. Annual Greenland halibut landings and total allowable catch (TAC) since 1970. Data for 2010 are preliminary.

RESOURCE ASSESSMENT

The status of the resource is determined by examining indicators from the DFO's research survey, the July sentinel survey, and from the commercial fishery. These indicators concern the stock's abundance and general condition as well as the fishery success. In order to assess the significance of the changes, the value of the 2010 indicators was compared with the average from the last ten years (2000-2009). The average related to the complete series (1990-2009) is also presented for the DFO research survey indicators.

The significance of recruitment to the population (one-year-old fish) is characterized based on their abundance index value (in millions of fish) recorded from the research survey. These values, which are arranged in ascending order, were divided into four large categories based on their relative level between 1990 and 2010. They were represented as follows (Figure 3): Low: 0-50; Average: 50-100; Good: 100-150; High: above 150. Furthermore, the 1992, 1993 and 1994 year-classes represent the lowest abundance level (less than 20) and the 1997 and 1999 year-classes represent the highest level of the series (more than 200).

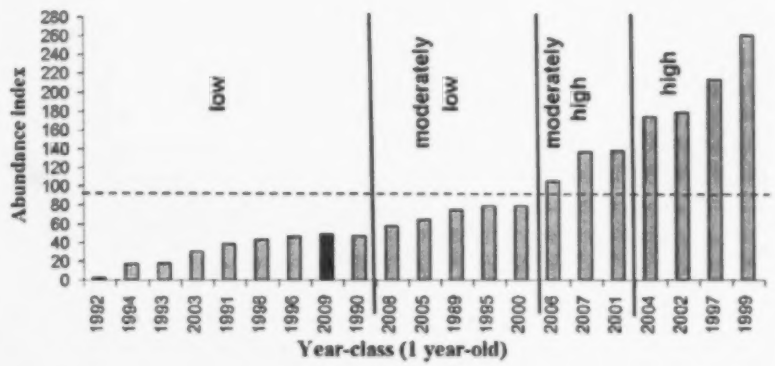


Figure 3. Recruitment to the population abundance index (year-class - 1 year-old) of Greenland halibut calculated from the research survey from 1990 to 2010. The significance of recruitment is presented in four categories (low, average, good and high). The dotted line represents the series average (1990-2010).

Surveys

A research survey is conducted annually in the Estuary and Gulf of St. Lawrence in August on board a DFO vessel. Between 1990 and 2003, the survey was conducted on board the CCGS *Alfred Needler*. It was then replaced by the CCGS *Teleost*. Following some comparative fishing experiments between the two vessels, catches by the CCGS *Alfred Needler* between 1990 and 2003 were corrected to match the catches made by the CCGS *Teleost*.

The cod sentinel fishery survey, conducted in July in the northern Gulf since 1995, is also used for determining the status of the resource. This survey is conducted by nine otter trawlers according to a stratified sampling plan. It does not cover the St. Lawrence Estuary, where 14% (13% over the last ten years and 18% for the whole time series) of the Greenland halibut biomass was located in 2010, this area is known for the presence of small turbot .

For these two surveys (DFO and sentinel), indices for overall biomass and exploitable stock biomass (44+) were calculated. Abundance indices per size class such as recruitment to the population (fish of less than 30 cm and 1-2 year-olds), pre-recruits (fish of 40-43 cm entering the fishery the following year), and fish above the minimum legal size (44+ cm) also serve as stock status indicators. Furthermore, abundance indices per region are also calculated; the western Gulf (including the Estuary and southern Anticosti), northern Anticosti and Esquiman Channel (Figure 4).

Data on the sexual maturity of males and females have been gathered since 1996 during DFO missions in August, i.e. several months before spawning. Sexual maturity is assessed according to morphological criteria for all fish measured during these missions. A maturity ogive is then calculated for estimating the length at which 50% of fish are mature (L50) for both males and females. The Fulton condition index (fish weight/cubed length) was calculated for fish of 40+ cm. This index provides information on the physical condition of the fish.

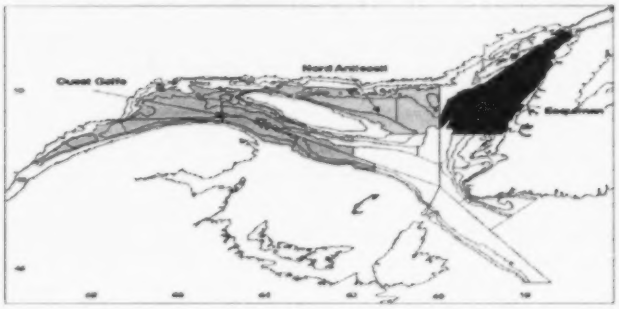


Figure 4. Reference areas for calculating biomass per region.

Commercial Fishery

Commercial fishery statistics and logbooks from traditional gillnetters (6-inch mesh) from Quebec and Newfoundland have been used to estimate catches per unit of effort (CPUEs) since 1996. The CPUE is defined as the weight in kg of Greenland halibut caught in a net per trip. The gross values are standardized to account for changes based on NAFO subarea 4Si, soak time (three days) and seasonal pattern (July).

The mean size of fish caught in gillnets from commercial samples is also calculated.

Resource Status in 2010

Since 2006, commercial fishing sites have expanded in the south-west and north of Anticosti. The surveys indicate no significant difference in the distribution pattern of the stock in 2010. Between 2007 and 2009, the biomass index fell by 37% and 46% and the abundance index of fish available to the fishery (44+ cm) by 40% and 41% for the DFO research survey and sentinel fisheries survey, respectively (Figure 5). A substantial decrease was also observed between 2008 and 2009 in the abundance of pre-recruits to the fishery (40-43 cm) in both surveys. The significant decline observed in the biomass indices (kg/tow) from the two surveys between 2007 and 2009, stopped in 2010, but the indices are still below the average of the last ten years. In recent years, biomass has decreased by half in the Esquiman channel and north of Anticosti and there was an upward trend in the western Gulf. However, in 2009, the indices showed a significant decrease in biomass in the western Gulf and no significant difference in Esquiman and north of Anticosti compared to 2008. The proportion of biomass recorded in the western Gulf accounts for 73% of the total biomass in 2010, with 14% in the Estuary. The 1990-2010 series average was 74% and 18% in the Estuary.

The abundance of recruitment to the population (one year-olds) observed between 2006 and 2008 was at a *moderately low* to *moderately high* level (Figure 3). However, the 2009 cohort was *low*. The last five years represent the longest period since the late 1990s when there was

no production of *strong* recruitment. Size at first maturity showed a deterioration between 1996 and 2001 and has since remained at a level below the series average.

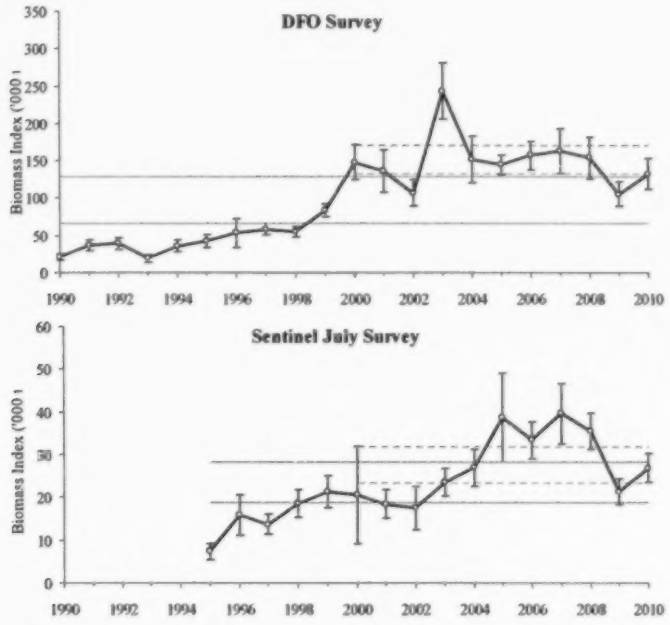


Figure 5. Minimum trawlable biomass indices for Greenland halibut in Divisions 4RST estimated from the DFO research survey and the July sentinel survey ± confidence interval (95%). The horizontal lines represent the average limits ± 0.5 standard deviation for the 2000-2009 period (dotted lines) and for the entire series (solid lines).

Performance by commercial fishermen for the entire Gulf dropped by 15% in 2010 compared to 2009. However, catch rates by region showed a significant increase in 2009 in Esquiman and north of Anticosti followed by a drop in 2010 and a decrease in the western Gulf (Figure 6), where over 70% of catches were made. In the early 2000s, low yields, a decrease in mean size, and an increase in the difference between the fixed gear allocations and landings reflected the fishing difficulties in the Gulf during this period. Since 2003, yields have improved significantly.

Stock Status Indicators

In the early 1990s, most abundance indicators were below the 1990-2009 average. The total biomass values at this period were the lowest in the 1990-2009 series. The distribution of the Greenland halibut stock was limited to the Estuary at the head of the Gulf channels. It seems that the recruitment of year-classes of higher abundance (1989 and 1995) resulted in an increase in productivity to the point that biomass and abundance indicators improved in the late 1990s and early 2000s. Subsequently, between 1998 and 2005, an alternation occurred between the production of juveniles of *strong* (1997, 1999, 2002 and 2004) and *average* to *weak* abundance (1998, 2000, 2003 and 2005). The 1997 and 1999 year-classes were the strongest cohorts observed so far. The general improvement of recruitment led to a substantial increase in biomass indices followed by a fairly stable period. Therefore, between 2000 and 2007, the values of the biomass index from the research survey were around the 2000-2009 average and they were below the average in 2009 and 2010.

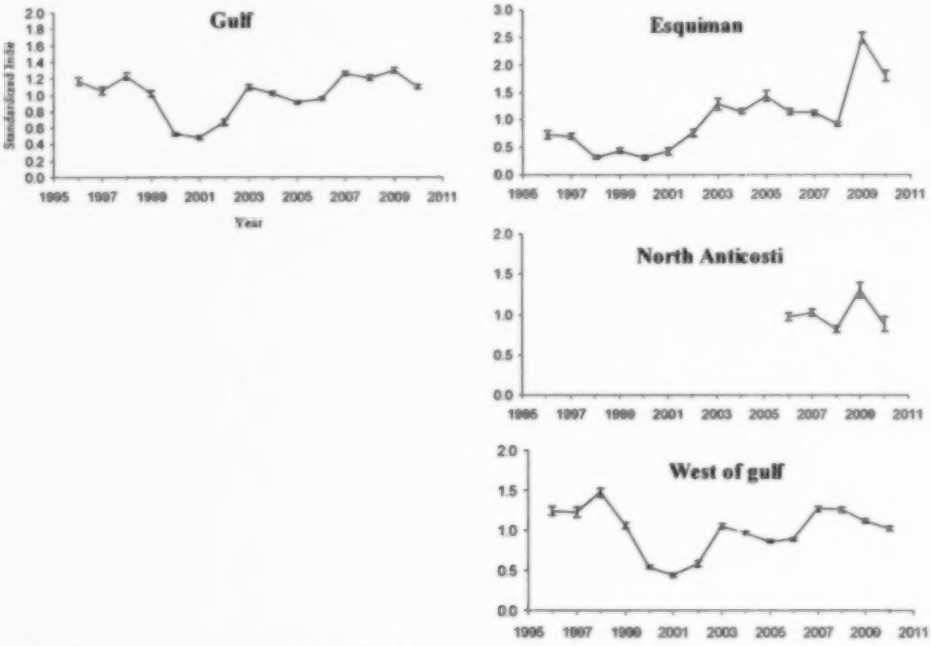


Figure 6. Standardized fishery indices for the Gulf and per region. The 95% confidence intervals are shown.

The abundance indices (in numbers) of fish that will be recruited to the fishery (44+ cm) presented a decrease between 2007 and 2009 and an increase in 2010 (Figure 7). The abundance indices of pre-recruits (40-43 cm) dropped sharply in both surveys in 2009 and remained at values lower than the 2000-2009 average in 2010 (Figure 7). The downward trend observed in recent years is explained in part by the presence of low abundant year-classes (2003 and 2005) contiguous to the 2004 year-class.

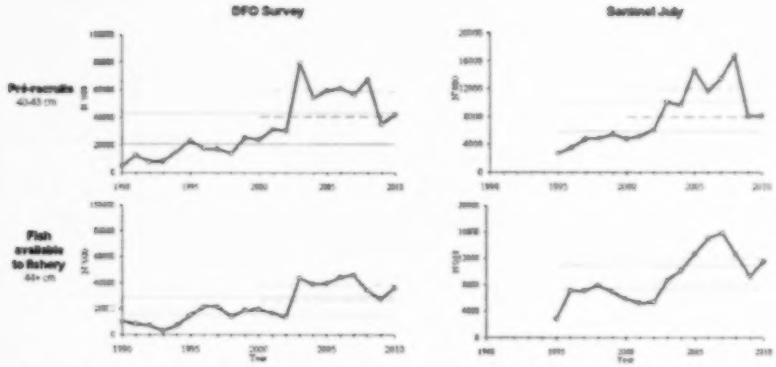


Figure 7. Abundance indices for pre-recruits and fish available to the Greenland halibut fishery in Divisions 4RST estimated for the DFO research survey and the July sentinel fishery survey. The horizontal lines represent the average limits ± 0.5 standard deviation for the 2000-2009 period (dotted lines) and for the entire series (solid lines).

Information regarding sexual maturity shows that the size at which 50% of fish are mature (L50) has dropped since 1996, from 40 cm to 36 cm for males and from 50 to 45 cm for females (Figure 8). The 2010 value has remained low for males and females and was below the series average (1996-2009).

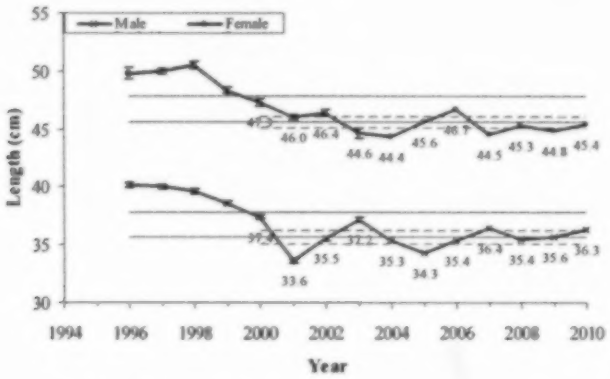


Figure 8. Size at 50% maturity for fish caught in the DFO research survey between 1996 and 2010. The horizontal lines represent the average limits ± 0.5 standard deviation for the 2000-2009 period (dotted lines) and for the entire series (solid lines).

The size at maturity for males is considerably lower than the minimum size of 44 cm established for the small fish protocol. Because the maximum size drops after reaching sexual maturity, there exists a size dimorphism between males and females that increases the proportion of females in commercial catches. Maturity ogives that estimate the proportion of mature individuals at length indicate that at 44 cm, 63% of females and 4% of males are immature. This proportion increased from 57% to 63% for females between 2009 and 2010. This change is a result of a size difference at maturity. The average number of immature individuals at 44 cm over the last four years is 60% for females and 4% for males.

The commercial fishery catch rate is used as an indicator of fishing success and not as an abundance index of the exploitable stock. The standardized values show a drastic increase in catch rates in Esquiman and north of Anticosti and a decrease in the western Gulf between 2008 and 2009. The fishing area north of Anticosti expanded in 2009. According to Industry, the sharing of this fishing area with shrimpers was better in 2009. It seems that the increase in yields in 2009 in Esquiman and north of Anticosti could be due in part to a high abundance of capelin in these areas. In fact, capelin by-catches by shrimpers more than tripled in 2009, mainly in this sector.

The standardized commercial catch rate for the entire Gulf showed some stability between 2007 and 2009 and a slight drop (15%) in 2010. The second fishery indicator, which was the mean size of fish caught in gillnets, increased from 47.3 to 49.3 cm between 2008 and 2010, and remained higher than the series average. A 1 cm increase was recorded in 4R and 4S and is explained by the decrease of individuals of < 44 cm as well as the increase of individuals of > 44 cm in the catches between 2009 and 2010.

The mean size of fish was around 43 cm in 1995, and rose to 48 cm in 1996 following the mesh size increase from 140 mm (5.5 in.) to 152mm (6.0 in).

Overall, the percentage of fish landed that were smaller than the legal size of 44cm decreased from 19% to 12% and to 9% from 2008 to 2010 respectively in 4RST. This proportion decreased even further in 4R (12% to 4% to 2%) and in 4S (20% to 12% to 9%), compared to 4T (23% to 22% to 17%). There have been more small fish caught in the west of the Estuary (4Tq and 4Tp).

The proportion of females in commercial catches has been higher on average since the mesh size increase was introduced in 1996 (mesh size increased from 5.5 in. to 6.0 in.). In 2010, it was 80%. This percentage appears to be rather stable since 2000.

Outlook

Recruitment of the two very abundant year-classes of 1997 and 1999 resulted in the abundance index increases observed in the early 2000s. Prior to the arrival of these year-classes, indices were at a low level. Subsequently, the fishery has targeted new and less abundant year-classes (2001 and 2002) than the 1997 and 1999 year-classes but that represent nonetheless two considerably abundant year-classes (Figure 3). Based on the research surveys, the portion of biomass available to the fishery decreased in 2008 and remained at a level below the five previous years, which was the result of the arrival of the weak 2003 and 2005 year-classes. The 2010 fishery was primarily made up of the only strong cohort of 2004 cohort.

In 2011, the 2006 cohort entering the fishery is of average abundance. The fishery will also be supported by the 2004 year-class for a third consecutive year, and by the weak year-class of 2005.

As mentioned in last year's assessment, a higher decrease than expected in terms of biomass available to the fishery and pre-recruits (40-43 cm) was observed in 2009. In light of this analysis, it was expected that larger fish would be less abundant in 2010, although some uncertainty about the magnitude of these changes was raised. The analyses indicated that the biomass available to the fishery in 2010 stopped declining and is at a level above the 2000-2009 average. However, the biomass of pre-recruits (40-43 cm) is still a level below average. For this reason, it seems likely that the portion of the biomass available to the fishery will decline in 2011.

The precautionary approach for Greenland halibut is being developed. A peer review was conducted in January 2009 to assess the methods for establishing reference levels (LRP: limit reference point and USR: upper stock reference). The method used is based on the temporal series of biomass indices (> 44 cm) from the surveys. The decision rules will then have to be developed in collaboration with Industry and fisheries management. These preliminary reference points indicated that the stock was still in the healthy zone in 2010, but the downward trend observed urges caution.

Sources of Uncertainty

The difference between the exploitable stock size indicators and fishing success observed in 2008 continued in 2010: the biomass of fish of 44+ cm from the DFO scientific survey and the sentinel fisheries survey decreased in 2009 and increased in 2010 while the CPUEs of the commercial fishery remained stable and then decreased in 2010 (Figure 9). It should be noted that the fishing success index is not used as a stock abundance index.

CPUEs declined in the western Gulf and Industry representatives indicated that a shift in effort was necessary in this area in 2009 and in 2010 to achieve acceptable yields.

The size at sexual maturity value in 2010 remained low and was below the 1996-2009 average for males and females. This indicator remains a concern for the preservation of the spawning stock.

CONCLUSIONS AND ADVICE

Fishery results were generally good in 2010. Commercial catch rates in the western Gulf, Esquiman and north of Anticosti showed a decrease in 2010, but they remain high in Esquiman. The survey biomass indices did not show any significant increase in Esquiman and showed a decrease in the western Gulf and north of Anticosti.

Given that the main resource status indicators and that the average abundance of upcoming year-classes (2006 and 2007) would indicate some stability in the fishery, it is recommended that the status quo be maintained in terms of the 2010 authorized catch levels for 2011-2012 and 2012-2013.

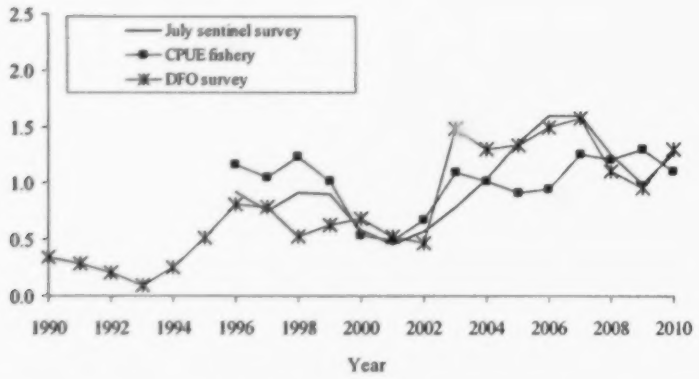


Figure 9. Standardized indices for exploitable stock biomass (44+ cm) for Greenland halibut and fishery CPUEs.

OTHER CONSIDERATIONS

Greenland halibut by-catches from the shrimp fishery from 1999 to 2010 were examined using the observers at sea database. Greenland halibut were present on average in 89% of the activities observed. Fish by-catches are mostly of the order of 1 kg or less per tow observed and 3 kg or less for turbot when observers are present. The presence of an observer does not appear to disrupt the general fishing pattern, as the catch rates with or without an observer do not vary.

Greenland halibut catches are mostly made up of 1 year-old individuals, and in a lesser extent 2 year-old individuals. They vary according to areas and years and appear to be largely influenced by fishing effort by shrimpers and fishing location. Consequently, the areas of Sept-Iles and Anticosti have the highest by-catch rates of Greenland halibut, and concentrations of juveniles (1 and 2 year-olds) were higher in these areas compared to Esquiman. The average

annual Greenland halibut by-catches from the shrimp fishery in the Estuary and Gulf from 1999 to 2010 are in the order of 100 tons. In 2010, shrimp fishery by-catches of Greenland halibut in the Estuary and Gulf totalled around 77 tons, which represents a 15% decrease from 2009.

SOURCES OF INFORMATION

This scientific advice results from the regional advisory meeting held on February 15, 2011 on the Assessment of the Greenland halibut Stock in the Gulf of St. Lawrence (4RST) from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat. Any other publication resulting from this process will be published when available on the calendar of scientific advice from the DFO Science Branch at the following address: http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

Bourdages H., D. Archambault, B. Bernier, A. Fréchet, J. Gauthier, F. Grégoire, J. Lambert and L. Savard. 2010. Preliminary results from the groudfish and shrimp multidisciplinary survey in August 2009 in the northern Gulf of St. Lawrence. Canadian Technical Report of Fisheries and Aquatic Science. 1226: xii + 72 p.

Morin, B. and B. Bernier. 2003. Assessment of Greenland Halibut (*Reinhardtius hippoglossoides*) in the Gulf of St. Lawrence (4RST) in 2002. Canadian Stock Assessment Secretariat. Research document 2003/088. 72 p.

FOR MORE INFORMATION

Contact: Alain Fréchet and Brigitte Bernier
Maurice Lamontagne Institute
850, route de la Mer, P.O. Box 1000
Mont-Joli, Quebec
G5H 3Z4

Tel: (418) 775-0628 and 775-0633
Fax: (418) 775-0679
E-Mail: Alain.Frechet@dfo-mpo.gc.ca and Brigitte.Bernier@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Quebec Region
Fisheries and Oceans Canada
Maurice Lamontagne Institute
P.O. Box 1000, Mont-Joli
Quebec (Canada)
G5H 3Z4

Telephone: (418) 775-0825
Fax: (418) 775-0679
E-Mail: Bras@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5109 (Printed)
ISSN 1919-5117 (On Line)
© Her Majesty the Queen in Right of Canada, 2011

La version française est disponible à l'adresse ci-dessus.

CORRECT CITATION FOR THIS PUBLICATION:

DFO. 2011. Assessment of the Greenland Halibut Stock in the Gulf of St. Lawrence (4RST) in 2010. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/013.